7. SUMMARY AND SUGGESTIONS FOR FUTURE WORK

7.1 SUMMARY

In the past there was a considerable interest in the study of new materials excellent optical nonlinearities and potential use in applications including telecommunication, optical computing, optical data storage and optical devices. The nonlinear optical (NLO) materials for second harmonic generation (SHG), optical parametric oscillation (OPO) or optical parametric amplification (OPA) have resulted in the development of numerous organic, inorganic and semi organic nonlinear optical crystals.

The chapter I dealt with an elaborate introduction of crystals growth. The various methods of crystal growth are explained in this chapter, with an emphasis to solution growth techniques. The scope of the thesis is presented in detail. In chapter II literature survey is made crystals are developed grown from inorganic, organic and semi organic materials. The theoretical concept of nonlinear optics is explained thoroughly.

In the chapter III an overview of various principles and instrumentation techniques, which are used to characterize the grown crystals are described. The principles, theory and instrumentation which involves in various characterization techniques, such as single XRD, powder XRD, FT-IR, UV-Vis-NIR spectra, thermal, hardness, SHG efficiency and Z-scan studies are presented in detail.

Chapter IV discussed the growth, thermal, mechanical, linear and nonlinear optical properties of pure and potassium doped meta-Nitroaniline single crystals. Good quality single crystals of pure and potassium-doped meta-Nitroaniline crystals were grown by slow evaporation method using methanol as solvent. Transparent single crystals of mNAK with dimensions 15×6×3 mm³ were obtained after 25 days. Simultaneously, a pure mNA crystal was grown using the same procedure. The presence of potassium in mNAK was confirmed by EDX analysis. The lattice parameters were found by single crystal XRD study and are in good agreement with the reported
values. From the powder XRD studies, the various planes of reflection of the crystals were identified and indexed. The pure and doped crystals belong to orthorhombic system having space group of Pbc21. Vibration frequencies from FT-IR spectral analysis confirmed the presence of all functional groups. The DTA curves show an endothermic peak at 114ºC, which corresponds to the melting point of mNAK. By Vicker’s microhardness technique, the crystal was identified as grown crystals which are soft material categories. From optical transmittance study, the UV cut-off wavelength of the mNA and mNAK crystals was measured to be 345 nm and 352 nm. The crystals show good absorbance in the entire UV region and transmittance in the entire visible and near-infrared regions. Refractive index and optical band gap of mNAK were 1.51 and 3.76 eV., SHG efficiency of the mNA and mNAK crystalline sample is 1.27, 1.988 times than that of the standard KDP crystal. The nonlinear optical parameter value of mNA and mNAK crystals are nonlinear refractive index $n_2 = 1.43 \times 10^{-8}$ (cm$^2$/W), nonlinear absorption $\beta = 2.82 \times 10^{-4}$ (cm / W), nonlinear susceptibility $\chi^{(3)} = 1.53 \times 10^{-6}$ esu nonlinear refractive index $n_2 = 3.03 \times 10^{-8}$ (cm$^2$/W), nonlinear absorption $\beta = 4.24 \times 10^{-4}$ (cm / W), nonlinear susceptibility $\chi^{(3)} = 1.73 \times 10^{-6}$ esu.

Chapter V dealt with the growth and characterization of potassium dichromate (KDC) single crystals. The single crystal of potassium dichromate (KDC) was successfully grown from an aqueous solution using slow evaporation technique. The grown appreciable size of the order of $15 \times 8 \times 5$ mm$^3$ was reported in a period of 22 days. The single crystal X-ray and Powder X-ray diffraction studies confirm the triclinic structure of KDC with space group $P\overline{1}$. The lattice parameters obtained as, $a = 7.38$ Å, $b = 7.46$ Å, $c = 13.38$ Å, $\alpha = 95.19^\circ$, $\beta = 98.06^\circ$, $\gamma = 90.93^\circ$ and the volume of the unit cell is found to be $724.0$ Å$^3$. The UV cut off wavelength of KDC is found to be at 240 nm. TG-DTA studies revealed that the crystal is thermally stable up to 397.1°C. The mechanical and etching studies of the grown crystal was carried out. Absence of second harmonic generation in this material confirms the Centro-symmetric nature of the grown crystal. Closed aperture Z-scan study reveals the negative nonlinearity in the crystals and open aperture
Z-scan the saturation absorption. The nonlinear optical parameter value of nonlinear refractive index $n_2 = 9.41 \times 10^{-8}$ (cm$^2$/W), nonlinear absorption $\beta = 0.57 \times 10^{-4}$ (cm/W), nonlinear susceptibility $\chi^{(3)} = 4.68 \times 10^{-6}$ esu. The third order nonlinear properties confirm its suitability for nonlinear optical devices, such as optical limiting and optical switching.

The chapter VI is devoted to study the effect of KDP on the growth, thermal and optical properties of L-alanine single crystal single crystal of L-alanine has been grown from aqueous solution of potassium di hydrogen phosphate (KDP) by slow evaporation method. The single crystal X-ray diffraction study confirms that the title crystal belongs to the orthorhombic structure with the space group $P2_1 2_1 2_1$. The presence of functional groups was determined using FT-IR analysis. The presence of phosphate observed very strong band occurring at 539 cm$^{-1}$ in the FT-IR spectrum. UV-visible-NIR Spectrum of L-alanine shows 73% transparency in visible region and its band gap energy is found to be 4.9 eV. The grown crystals are thermally stable up to 288.7°C. The SHG efficiency of the L-alanine is 1.022 times than that of the standard KDP crystal. The presence of phosphate in enhancement of SHG and variation in thermal behavior for the L-alanine crystal grown in present study impact to the pure L-alanine are due to the presence of KDP in the growth solution. The Z-scan measurements further confirm that the material exhibit large third order nonlinear optical properties. The nonlinear optical parameter values such as, nonlinear refractive index $n_2 = 8.82 \times 10^{-8}$ (cm$^2$/W), nonlinear absorption $\beta = 0.15 \times 10^{-4}$ (cm/W), nonlinear susceptibility $\chi^{(3)} = 4.31 \times 10^{-6}$ esu. The third order nonlinear parameters are highly encouraging for this crystal. All these studies indicate that the grown crystal is the potential material for second harmonic as well as third harmonic generation applications.
7.2 SUGGESTIONS FOR FUTURE WORK

The single crystals are found application in the development of technologies such as Laser, semiconductor, high and low energy particles. The nonlinear optical materials play important role in the field optical communication, frequency conversion, optical switching devices etc.,

- It is possible to grow bulk size crystals of mNA, mNAK, KDC, L-alanine crystals with improved optical quality by carefully adopting either the slow cooling method or by some innovative techniques with modified apparatus. Attempts could be made in future to investigate the nucleation parameters such as metastable zone width, induction period, interfacial tension etc.,

- The dopants in the crystal lattice play a significant role in improving morphology and second harmonic generation (SHG) efficiency of the crystal. Hence, by adding rare earth compounds as the dopant in different concentration morphology and SHG efficiency can be studied.

- The laser damage threshold studies could be carried out on the grown crystals with improved optical quality and the variation of laser damage threshold with the beam energy could be correlated.

- Further, phase matching and other higher harmonic generation studies can be made on the grown crystals.